

## What is SCR?

Selective Catalytic Reduction (SCR) is a way of reducing oxides of nitrogen (NOx) emissions from diesel engines and other pollution sources. It works by adding a small amount of a reductant chemical to the exhaust upstream from a catalyst. The reductant reacts with the NOx to produce harmless nitrogen gas and water.

SCR has been used for more than 30 years on stationary pollution sources such as power plants, but until now the size, weight, and cost of SCR systems have made them impractical for mobile applications.

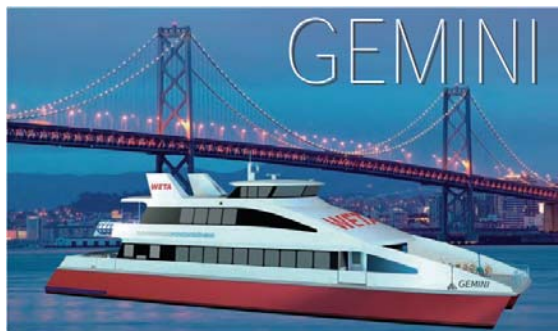
## What's different about the EF&EE Compact SCR™ system?

EF&EE's Compact SCR™ systems use new technology originally developed for heavy-duty diesel truck engines to meet Euro 5 emission standards. Similar technology will be used on 2010 truck engines in the U.S. Compared to SCR systems designed for stationary sources, Compact SCR systems are about 1/5th the size and weight, making them practical to retrofit to many existing vehicles.

EF&EE's Compact SCR™ systems are designed for ruggedness and reliability in vehicular use. Economies of mass production in the key components make it highly cost-effective.

The reductant used in Compact SCR™ systems is a non-hazardous solution of urea in water. Urea is widely used as fertilizer. The volume of solution required is typically between 2% and 6% of diesel fuel consumption.

Compact SCR™ systems can reduce diesel NOx emissions up to 97%, depending on the exhaust temperature. They also work as diesel oxidation catalysts, reducing PM emissions by 30 to 60%, HC by 80%, and CO by more than 90%.

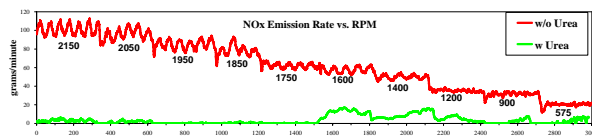


## Compact SCR™ in Harborcraft

**New construction** –The ferries *Gemini* and *Pisces* are the first two of four similar vessels designed with Compact SCR™ systems on their 1410 horsepower main engines. All four boats were ordered by the Water Emergency Transit Authority (WETA) for service in San Francisco Bay. To mitigate the environmental impact of new ferry services, the WETA specification required cruise emissions from the new boats to be 85% below Tier 2 levels. Acceptance testing showed the actual emissions to be 96% below Tier 2, and within Tier 4 emission limits. NOx was reduced by 97% and PM by about 60% compared to engine-out emissions.

M.V. Gemini Acceptance Testing		
85% Power Cruise	Emissions (g/kWh)	
	Port	Starboard
NOx	0.01	0.18
PM	0.048	0.021
CO	0.04	0.10
HC (est.)	0.02	0.02
NOx+PM+HC	0.08	0.22
WETA Contract	1.11	
EPA Tier 2	7.4	

M.V. Pisces Acceptance Testing		
85% Power Cruise	Emissions (g/kWh)	
	Port	Starboard
NOx	0.18	0.28
PM	0.023	0.022
CO	0.02	0.03
HC (est.)	0.02	0.02
NOx+PM+HC	0.22	0.32
WETA Contract	1.11	
EPA Tier 2	7.4	



## M.V. Gemini – starboard engine SCR calibration data

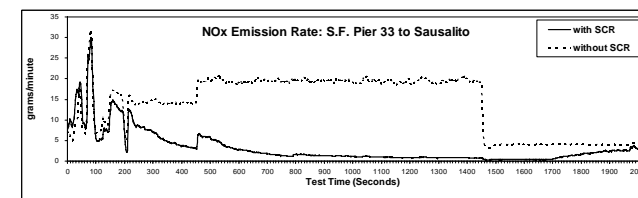
**Retrofit** – Under an agreement with the National Park Service, Compact SCR™ systems have been retrofit to the main and generator engines in two passenger ferries plying between

San Francisco and Alcatraz Island. The first vessel, *Alcatraz Flyer*, returned to service in February, 2008, and has accumulated more than 2800 operating hours to date. The second, *Alcatraz Clipper*, re-entered service in September, 2008, and has accumulated more than 1800 operating hours.

The Alcatraz ferries are equipped with two 625 hp main engines each. The Compact SCR™ catalyst assemblies for these engines are 44 x 51 x 16 inches, and weigh about 350 pounds. They easily fit in the existing engine room.



Compact SCR installation in M.V. Alcatraz Clipper



Effect of Compact SCR™ on NOx for a typical trip

**CARB rules and funding opportunities** – The Carl Moyer Program and similar grants have paid for repowering many California vessels. Adding Compact SCR™ to a repower grant proposal can double or triple the emission reductions, improving the cost-effectiveness and increasing the maximum grant available.

A new CARB rule makes repowering and/or emission control retrofits mandatory for most harborcraft between 2011 and 2016. To be eligible for grant funding, these retrofits must be completed three years before the deadline. Compact SCR™ systems are available today to allow many existing engines to meet this rule.

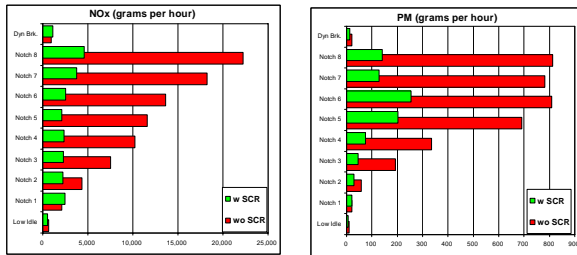
## Compact SCR™ in Locomotives

High shock and vibration, limited space, and extended periods of engine idling make railway locomotives one of the most challenging applications for SCR.

In February 2009, a Metrolink F59PH became the first SCR-equipped locomotive in North America. A specially-designed, shock-mounted Compact SCR™ catalyst assembly replaced the silencer on the locomotive's 3000 hp EMD 12-710G3 diesel engine. The Compact SCR™ control system monitors engine RPM, throttle notch setting, and tractive power output, and adjusts the urea injection rate accordingly. Emission results are shown in the graphs below. NOx emissions were reduced by 72% and PM by 78% over the EPA line-haul cycle.

As of the end of March, the Compact SCR™ unit had accumulated more than 400 operating hours in commuter rail service. During this time it prevented more than 600 kg of NOx and 25 kg of PM emissions, with no evidence of plugging or catalyst deterioration to date.

**EMD 12-710G3 Emissions**



## Gensets and CHP Systems

Strict emission limits have stymied the advance of combined heat-and-power (CHP) and other distributed generation technologies using internal combustion engines. In cooperation with the San Joaquin Valley Unified Air Pollution Control District and a major dairy, EF&EE is demonstrating Compact SCR™ in a combined heat-and-power system using biogas produced from cow manure and dairy waste. System startup is scheduled for April, 2009. This project is expected to lead the Air District to accept Compact SCR™ as BACT for biogas engines.



### Compact SCR™ in

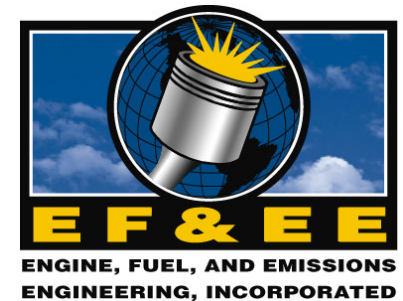
## Mobile Equipment

New CARB regulations on construction machinery and cargo-handling equipment will require most of these machines to be replaced or retrofit with emission controls. Compact SCR™ technology has been demonstrated successfully in on-road tractor trailers, and in generating sets like those used on rubber-tired gantry cranes. A system combining Compact SCR™ with a diesel particulate filter will begin demonstration on a D9 bulldozer in April, 2009.



# COMPACT SCR™

## Emission Control Technology for Diesel Engines



3215 Luyung Drive  
Rancho Cordova, CA 95742  
Ph. (916) 368-4770  
Fax (916) 362-2579  
[www.efee.com](http://www.efee.com)